CHAPTER 3

PAVEMENT CONDITION SURVEY AND RATING PROCEDURES

3-1. Introduction

An important component of PAVER is the pavement condition survey and rating procedures. Data obtained from these procedures are the primary basis for determining M&R requirements and priorities. This chapter explains how to conduct a condition survey inspection and how to determine the pavement condition index (PCI). It is essential to have a thorough working knowledge of the PCI and condition survey inspection techniques.

3-2. Pavement condition rating

Pavement condition is related to several factors, including structural integrity, structural capacity, roughness, skid resistance/hydroplaning potential, and rate of deterioration. Direct measurement of all of these factors requires expensive equipment and highly trained personnel. However, these factors can be assessed by observing and measuring distress in the pavement.

    a. PCI. The pavement condition rating is based on the PCI, which is a numerical indicator based on a scale of 0 to 100. The PCI measures the pavement's structural integrity and surface operational condition. Its scale and associated ratings are shown in figure 3-1.

    b. Determination of PCI. The PCI is determined by measuring pavement distress. The method has been field tested and has proven to be a useful device for determining M&R needs and priorities.

3-3. Pavement inspection.

    a. General. Before a pavement network is inspected, it must be divided into branches, sections, and sample units as described in chapter 2. Once this division is complete, survey data can be obtained and the PCI of each section determined.

    b. Inspection procedures for jointed concrete pavement sections. There are two methods which may be used to inspect a pavement. Both methods require that the pavement section be divided into sample units. The first method-entire section inspection-requires that all sample units of an entire pavement section be inspected. The second method-inspection by sampling-requires that only a portion of the sample units in a section be inspected. For both methods, the sample units must be assigned sample unit numbers.

Figure 3-1. PCI scale and condition rating.

(1) For entire section inspections, the inspector walks over each slab in each sample unit and records the distress(es) observed on DA Form 5145-R (Concrete Pavement Inspection Sheet) (fig E-1). One form is used for each sample unit. The inspector sketches the sample unit using the preprinted dots as joint intersections (imaginary joints should be labeled). The appropriate number code for each distress found in the slab is entered in the square representing the slab. The letter *L* (low), *M* (medium), or *H* (high) is included along with the distress number code to indicate the severity level of the distress. Distresses and severity level definitions are listed in appendix B. Since the PCI was based on these definitions, it is imperative that the inspector follow appendix B closely when performing an inspection.

(2) The equipment needed to perform a survey is a hand odometer for measuring slab size, a 10-foot straightedge and rule for measuring faulting and land/shoulder drop off, and the PCI distress guide (app B).

(3) The Inspection Sheet has space for a summary of each distress and severity level(s) of distress contained in the sample unit. These data are used to compute the PCI for the sample unit as outlined in paragraph 3-5. Figure 3-2 is an example of DA Form 5145-R showing the summary of distresses for the sample unit.

c. Inspection procedures for asphalt, tar-surfaced, and/or asphalt over concrete pavement. As with jointed concrete pavements, the pavement section must first be divided into sample units. During either the entire section inspection or inspection by sampling, the inspector walks over each sample unit, measures each distress type and severity, and records the data on the DA Form 5146-R, Asphalt Pavement Inspection Sheet (fig E-2).

(1) The equipment needed is a hand odometer used to measure distress lengths and areas, a 10-foot straightedge, and a ruler to measure the depth of ruts or depressions.

(2) One form is used for each sample unit. One column on the form is used to represent each identified distress type. The number of that distress type is indicated at the top of the column. Amount and severity of each distress identified is listed in the appropriate column. An example of a completed DA Form 5146-R Asphalt Pavement Inspection Sheet is shown at figure 3-3. Distress No. 6 (depression) is recorded as *6x4L*, which indicates that the depression is a 6-foot by 4=foot area and of low severity. Distress No. 10 (longitudinal and transverse cracking) is measured in linear feet; 3-2 thus, *10L* indicates 10 linear feet of light cracking, etc. The total distress data are used to

compute the PCI for the sample unit. That computation is explained later in paragraph 3-5. An example of the summary of the distress types densities and severities for an asphaltor tar-surfaced sample unit is shown in figure 3-3.

d. Remarks.

(1) For both jointed concrete and asphalt or tar-surfaced pavement, it is important that each sample unit be identified concisely so it can be located for additional inspections, comparison with future inspections, maintenance requirements, and random sampling purposes. One way to do this is to keep a file of previous inspection data, including a sketch of the section which shows the location of each sample unit. (See fig 2-5 as an example.)

(2) It is imperative that the distress definitions listed in appendix B be used when performing pavement inspections. If these definitions are not followed, an accurate PCI cannot be determined.

3-4. Inspection by sampling

a. General. Inspection of every sample unit in a pavement section may be necessary if exact quantities are needed for contracting; however, such inspections require considerable effort, especially if the section is large. Because of the time and effort involved, frequent surveys of an entire section subjected to heavy traffic volume may be beyond available manpower, funds, and time. Therefore, sampling plans have been developed to allow adequate determination of the PCI and M&R requirements by inspecting only a portion of the sample units in a pavement section. The sampling plans can reduce inspection time considerably and still provide the accuracy required. The number and location of sample units to be inspected is dependent on the purpose of inspection. If the purpose is to determine the overall condition of the pavement in the network (e.g., initial inspection to identify projects, budget needs, etc.), then a survey of one or two sample units per section may suffice. The units should be selected to be representative of the overall condition of the section. If the purpose, however, is to analyze various M&R alternatives for a given pavement section (e.g., project design, etc.), then more sampling should be performed. The following paragraphs present the sampling procedure for this purpose.

b. Determining the number of samples.

(1) The first step in performing inspection by sampling is to determine the minimum number of sample units *(n)* that must be surveyed. This is done by using figure 3-4.

CONCRETE PAVEMENT INSPECTION SHEET
For use of is form, see TM 5-623; the proponent agency is USACE.

BRANCH _MARSHALL AVE_ SECTION ___1___

DATE _10 / 3 / 79_ SAMPLE UNIT ___1___

SURVEYED BY ___SK___ SLAB SIZE ___15' x 20'___

Distress Types

21. Blow-Up Buckling/Shattering	31. Polished Aggregate
22. Corner Break	32. Popouts
23. Divided Slab	33. Pumping
24. Durability ("D") Cracking	34. Punchout
25. Faulting	35. Railroad Crossing
26. Joint Seal Damage	36. Scaling/Map Cracking/Crazing
27. Lane/Shldr Drop Off	
28. Linear Cracking	37. Shrinkage Cracks
29. Patching, Large & Util Cuts	38. Spalling, Corner
	39. Spalling, U Joint
30. Patching, Small	

DIST. TYPE	SEV.	NO. SLABS	% SLABS	DEDUCT VALUE
26*	M	////////	////////	4
22	L	1	5	4
22	M	1	5	8
28	L	1	5	3
28	M	2	10	9
38	L	2	10	1

q= 2   TOTAL DEDUCT VALUE   **29**

CORRECTED DEDUCT VALUE (CDV)   **24**

PCI = 100 - CDV = __76__

RATING = _VERY GOOD_

Grid labels (left, rows 1–10, columns 1–4):
- 28L
- 38L
- 28M
- 38L
- 22L
- 22M
- 28M

* All Distresses Are Counted On A Slab-By-Slab Basis Except Distress 26, Which Is Rated For the Entire Sample Unit.

DA FORM 5145-R, NOV 82

Figure 3-2. An example of a completed DA Form 5145-R, Concrete Pavement Inspection Sheet.

ASPHALT PAVEMENT INSPECTION SHEET
For use of this form, see TM 5-623; the proponent agency is USACE.

BRANCH _MOTORPOOL RD._ SECTION ___1___

DATE ___10 / 2 / 79___ SAMPLE UNIT ___1___

SURVEYED BY ___SK___ AREA OF SAMPLE ___2500___

Distress Types

1. Alligator Cracking
2. Bleeding
3. Block Cracking
*4. Bumps and Sags
5. Corrugation
6. Depression
*7. Edge Cracking
*8. Jt Reflection Cracking
*9. Lane/Shldr Drop Off

*10. Long & Trans Cracking
11. Patching & Util Cut Patching
12. Polished Aggregate
*13. Potholes
14. Railroad Crossing
15. Rutting
16. Shoving
17. Slippage Cracking
18. Swell
19. Weathering and Raveling

SKETCH:

100'

N

DIRECTION SURVEYED

25'

EXISTING DISTRESS TYPE QUANTITY & SEVERITY

TYPE →	10	1	15	6		
QUANTITY & SEVERITY	10 L	1×6 L	2×25L	6×4 L		
	5 L	2×8M				
	15 L					
	5M					
	10 L					
	5M					
TOTAL SEVERITY L	40	6	50	24		
M	10	16				
H						

PCI CALCULATION

DISTRESS TYPE	DENSITY	SEVERITY	DEDUCT VALUE	
1	0.24	L	4	PCI = 100 – CDV =
1	0.64	M	17	
6	0.96	L	4	67
10	1.60	L	4	
10	0.4	M	3	
15	2.0	L	13	
				RATING = GOOD
q= 2 TOTAL DEDUCT VALUE			45	
CORRECTED DEDUCT VALUE (CDV)			33	

* All Distresses Are Measured In Square Feet Except Distresses 4,7,8,9 and 10 Which Are Measured In Linear Ft; Distress 13 Is Measured In Number of Potholes.

DA FORM 5146-R, NOV 82

Figure 3-3. An example of a completed DA Form 5146-R, Asphalt Pavement Inspection Sheet.

(2) The curves shown in figure 3-4 are used to select the minimum number of sample units that must be inspected. This will provide a reasonable estimate of the true mean PCI of the section. The estimate is within plus or minus 5 points of the true mean PCI about 95 percent of the time. When performing the initial inspection, the PCI range for a pavement section (i.e., lowest sample unit PCI subtracted from the highest sample unit PCI) is assumed to be 25 for asphalt concrete (AC) surfaced pavements and 35 for Portland cement concrete (PCC) surfaced pavements. For subsequent inspections, the actual PCI range (determined from the previous inspection) is used to determine the minimum number of sample units to be surveyed. As illustrated in figure 3-4, when the total number of samples within the section is less than five, every sample unit should be surveyed. If N is greater than five, at least five sample units should be surveyed.

(3) Examples of first assumption for number of sample units to be surveyed n follow:

(a) **Given**: Asphalt concrete pavement section with total number of sample units, N=20. **Find**: *n*.

Answer: Start at 20 on the N scale (fig 3-4), proceed vertically to the appropriate curve (PCI range= 25) and read 9 on the n scale. Nine sample units should be surveyed. If the PCI range is found to be within 25 the

sampling is complete. However, if the PCI range of the samples taken was found to be 40, it would be necessary to go back to figure 34. Start at 20 on the N scale again, proceed vertically to the curve PCI range=40, and read 13 on the n scale. In this unusual case it would be necessary to survey the additional 4 samples (9+4 = 13).
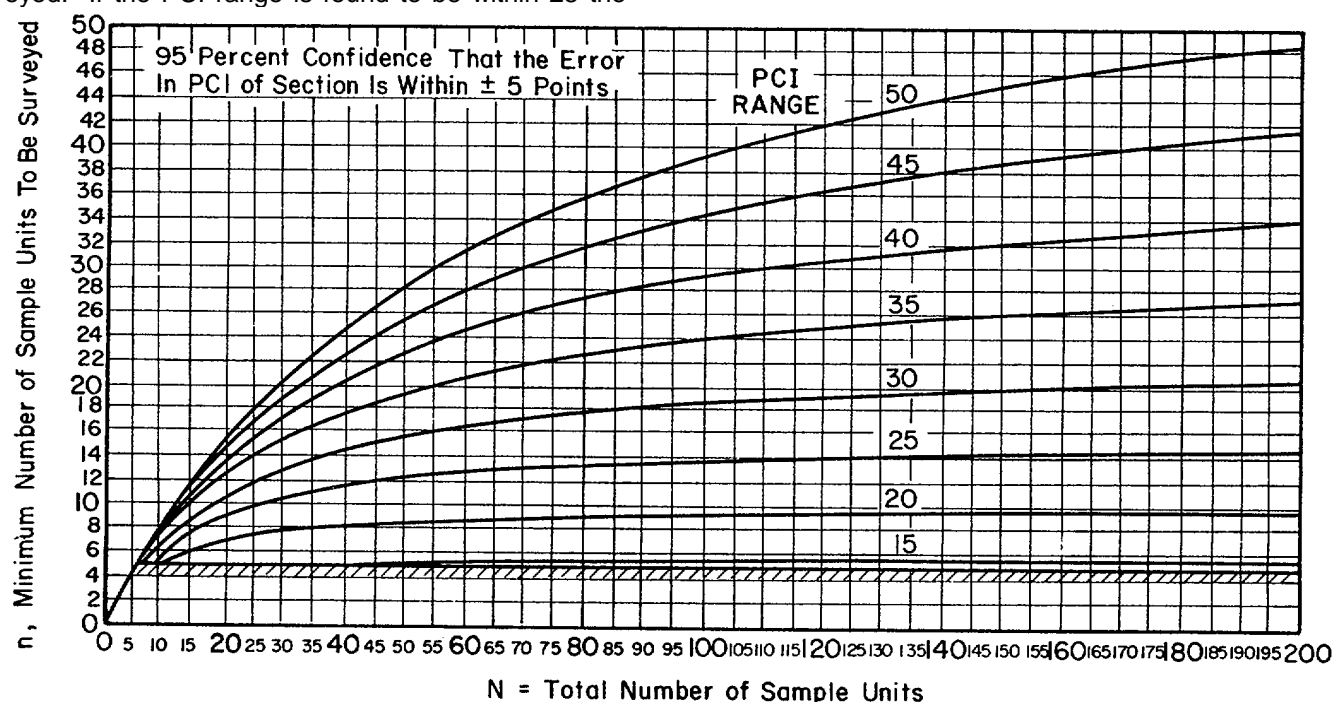
(b) **Given**: Portland cement concrete pavement section with *N*=30. **Find**: *n*.
Answer: Start at 30 on the N scale, proceed vertical to appropriate curve (PCI range=35) and read 15 on the *n* scale.

(c) **Given**: An AC or PCC pavement section with *N*<5. **Find**: *n*.
Answer: Survey all sample units.

c. Selection of samples. Determining specific sample units to inspect is as important as determining the minimum number of samples (n) to be surveyed. The recommended method for selecting the samples is to choose samples that are equally spaced; however, the first sample should be selected at random. This technique, known as systematic sampling, is illustrated in figure 3-5 and is briefly described below.

PCI = Pavement Condition Index
PCI RANGE = Highest Sample Unit PCI - Lowest Sample Unit PCI
Assumed PCI Range for asphalt Concrete =25
Assumed PCI Range for Portland Cement Concrete = 35

Figure 3-4. Determination of minimum number of sample units to be surveyed.

Total Number of Sample Units In Section (N) = 47

Minimum Number of Units To Be Surveyed (n) = 13

Interval (i) = $\dfrac{N}{n}$ = $\dfrac{47}{13}$ = 3.6   = 3
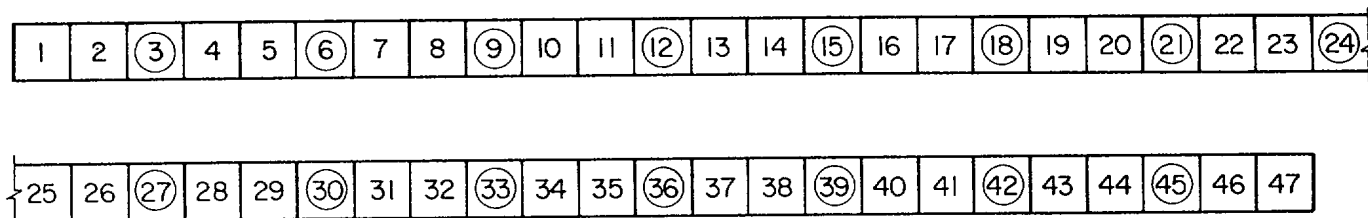
Random Start (S)   = 3

Figure 3-5. Example selection of sample units to be surveyed.

(1) The "sampling interval" (*i*) is determined by *i=N/n*, where *N*=total number of available sample units, *n*=minimum number of sample units to be surveyed, and *i* is rounded off to the smaller whole number (e.g., 3.6 is rounded to 3).

(2) The random start (*s*) is selected at random between 1 and the sampling interval (*i*). For example, if *i=3*, the random start would be a number from 1 to 3.

(3) The sample units to be surveyed are identified as *s, s+i, s+2i, s+3i,* etc. If the selected start is 3, then the samples to be surveyed are 3, 6, 9, 12, etc. (See fig 3-5.) This technique is simple to apply and also gives the information necessary to establish a PCI profile along the pavement section.

d. Selection of additional sample units. One of the major objections to sampling is the problem of not including very "poor" or "excellent" sample units which may exist in a section. Another problem is the selection of a random sample which contains nontypical distresses such a railroad crossings, potholes, etc.

(1) To overcome these problems, the inspector should label unusual sample units as additional sample units. An additional unit implies that the sample was not selected at random and/or contains distress(es) which are not representative of the section.

(2) The calculation of the PCI when additional sample units are included is slightly altered and its described in paragraph 3-5.

**3-5. Calculating the PCI from inspection results**

a. General. Paragraph 3-4 described two ways of inspecting a pavement section; i.e., inspecting every unit in the section or inspecting by sampling. Data collected during either method of inspection are used to calculate the PCI. This paragraph explains how to calculate the PCI for a particular sample unit, and how to calculate the PCI for the entire pavement section. An important item in the calculation of the PCI is the "deduct value." A deduct value is a number from 0 to 100, with 0 indicating the distress has no impact on pavement condition, and 100 indicating an extremely serious distress which causes the pavement to fail.

b. Calculating sample unit PCI. Calculating the PCI for a sample unit is a simple procedure which involves five steps (see fig 3-6):

**Step 1. Inspect sample units: Determine distress types
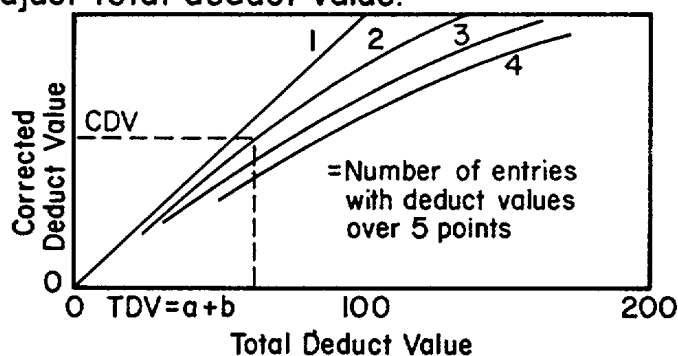and severity levels and measure density.**

Light L&T
Cracking

Medium Alligator
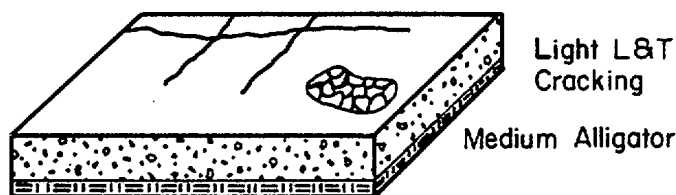
Step 2. Determine deduct values.

L & T Cracking

Alligator
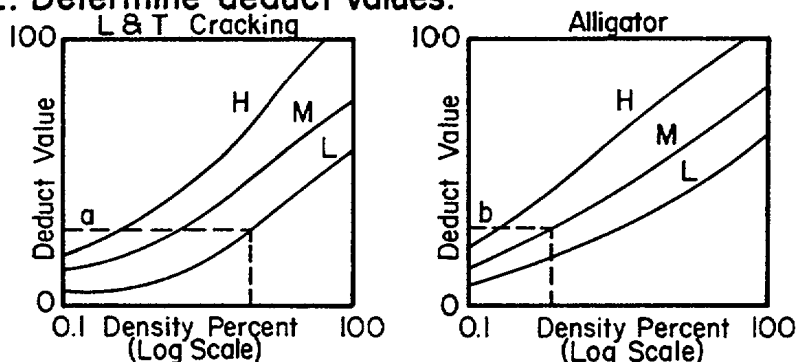
Step 3. Compute total deduct value (TDV) a+b.

Step 4. Adjust total deduct value.

CDV

=Number of entries
with deduct values
over 5 points

TDV=a+b   100   200

Total Deduct Value

**Step 5. Compute pavement condition index (PCI) =100 -CDV for each
sample unit inspected**

Figure 3-6. Steps for calculating PCI for a sample unit.

(1) Step 1. Each sample unit is inspected and distress data recorded on DA Form 5145-R for concrete or DA Form 5146-R for bituminous pavements as described in paragraph 3-3. (See figs 3-2 and 3-3.)

(2) Step 2. The deduct values are determined from the deduct value curves for each distress type and severity. (See app C.)

(3) Step 3. A total deduct value (TDV) is computed by summing all individual deduct values.

(4) Step 4. Once the TDV is computed, the corrected deduct value (CDV) can be determined from the correction curves (fig C-20 or fig C-40). When determining the CDV, if any individual deduct value is higher than the CDV, the CDV is set equal to the highest

individual deduct value. For example, assume that two distresses were found in an asphalt pavement, one with a deduct value of 50, and the other with a deduct value of 10. Using figure C-20, the CDV for q=2 (q = number of individual deducts whose value is greater than 5) is 44. Since 44 is lower than 50, the CDV is set equal to 50.

(5) Step 5. The PCI is computed using the relation PCI = 100 CDV.

c. Calculating the PCI for a pavement section. If all sample units in a section are surveyed, the PCI of the section is computed by averaging the PCIs

of all its sample units. Inspection by sampling, however, requires a different approach. If all surveyed sample units are selected randomly, the PCI of the pavement section is determined by averaging the PCI of its sample units. If any additional sample units are inspected, a weighted average must be used. The weighted average is computed by using the following equation:

$$PCI_s = \frac{(N-A)(PCI_1 + A)(PCO_1) + A(PCO_2)}{N}$$

(Equation 3-1)

where PCI_s = PCI of pavement section, PCI_1 = average PCI of random samples, PCI_2 = average PCI of additional samples, N = total number of samples in the section, and A = number of additional samples inspected.

d. Example calculation of the PCI for a sample unit. The field data sheets described in paragraph 3-3 are always used when calculating the PCI of a sample unit.

(1) *Asphalt pavement inspection sheet (fig 3-3).*

(a) The difference between calculating a PCI for an asphalt sample unit and calculating a PCI for a concrete sample unit is in the way the distress density is determined.

1. Density for distresses measured by the square foot is calculated as follows:

$$Density = \frac{distress\ amount\ in\ square\ feet}{sample\ unit\ area\ in\ square\ feet} \times 100$$

2. Density for distresses measured by the linear foot (bumps, edge cracking, joint reflection cracking, lane/shoulder drop off, and longitudinal and transverse cracking) is calculated as follows (see appendix B for distress definitions):

$$Density = \frac{distress\ amount\ in\ linear\ feet}{sample\ unit\ area\ in\ square\ feet} \times 100$$

3. Density for distress measured by number (potholes) is calculated as follows:

$$Density = \frac{number\ of\ potholes}{sample\ unit\ area\ in\ square\ feet} \times 100$$

(b) After the distress density for each distress type/severity combination is calculated, the deduct values are determined from the distress deduct value curves in figures C-1 through C-19 of appendix C. The corrected deduct value (CDV) is determined from figure C-20 and is calculated as shown in figure 3-3.

(2) *Concrete pavement inspection sheet (fig 3-2).* After inspection, calculate the density of distress

as follows:

$$Density = \frac{number\ of\ slabs\ containing\ a\ particular\ type}{distress\ number\ of\ slabs\ in\ sample\ unit} \times 100$$

For example, two slabs in the pavement sample unit shown in figure 3-2 contained linear cracking (distress 28) at medium severity, so the density is calculated as 2 20X 100, or 10 percent. The deduct values are then determined for each distress combination from the distress deduct value curves given in figures C-21 through C-39. The CDV is determined from figure C-40, and the PCI is calculated as shown in figure 3-2.

e. Determination of distress quantities for a pavement section. When a pavement has been inspected by sampling, it is necessary to extrapolate the quantities and densities of distress over the entire pavement section to determine total quantities for the section.

(1) If all sample units surveyed were selected at random, the extrapolated quantity of a given distress of a given severity level would be determined as illustrated in the following example for medium-severity alligator cracking:

Section Information
Surface type: Asphalt concrete
Area: 24,500 square feet
Total number of sample units in the section: 10

Five sample units were surveyed at random, and the amount of medium-severity alligator cracking was determined as follows:

Sample Unit ID Number	Sample Unit Area, Square Feet	Medium-Severity Alligator Cracking, Square Feet
02	2500	100
04	2500	200
06	2500	150
08	2500	50
10	2000	100
Total Random	12,000	600

The average density for medium-severity alligator cracking is, therefore, 600/12,000 = 05. The extrapolated quantity is determined by multiplying the density by the section area, i.e., .05X24,500=1225 square feet.

(2) If additional sample units were included in the survey, the extrapolation process would be slightly different. In the example given in (1) above, assume that sample unit number 01 was surveyed as additional and that the amount of medium-severity alligator cracking

was measured as follows:

Additional Sample Unit ID	Sample Unit Area, Square Feet	Medium-Severity Alligator Cracking, Square Feet
01	2500	1000
Total Additional	2500	1000

Since 2500 square feet were surveyed as additional, the section's randomly surveyed area is, therefore, 24,500-2500=22,000 square feet. The extrapolated distress quantity is obtained by multiplying the distress density by the section's randomly surveyed area and then adding the amount of additional distress. In this example:

Extrapolated Distress Quantity $=.05 \times 22,000 + 1000$
$$=2100 \text{ square feet}$$